Use of Curricular and Extracurricular Assessments to Predict Performance on the United States Medical Licensing Examination (USMLE) Step 1: A Multi-Year Study

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Abstract

This paper studies student performance predictions based on the United States Medical Licensure Exam (USMLE) Step 1. Subjects were second-year medical students from academic years of 2002 through 2006 (n=711). Three measures of basic science knowledge (two curricular and one extracurricular) were evaluated as predictors of USMLE Step 1 scores. The USMLE Step 1 scores correlated with performance on Organ Systems (r=0.76), Human Structure (r=0.65), and CBSE (r=0.69). Accounting for 59% of variance in the USMLE Step 1 scores, Organ Systems course was a better predictor compared to Human Structure (R^2=42%), or CBSE (R^2=51%). Combined, the curricular and extracurricular courses accounted for nearly 70% of total variance in the Step 1 scores. The study concluded that curricular courses are good predictors of student performance on the USMLE Step 1, and their value as identifiers of students at risk for failure is promising.

In 1994, the United States Medical Licensure Examinations (USMLE) became the only way in which allopathic physicians could obtain medical licensure in the United States (Swanson, Ripkey & Case, 1996). The USMLE consists of four separate examinations, Step 1, Step 2 Clinical Knowledge (CK), Step 2 Clinical Skills (CS), and Step 3 (Federation of State Medical Boards and National Board of Medical Examiners, 2008). Since a passing scores on the USMLE Steps 1 and 2 are required for a candidate to provide medical care under supervision, i.e., to enter residency training, many medical schools have adopted policies that require passage of Steps 1 and 2 for promotion and graduation. The National Board of Medical Examiners (NBME) has not set a limit to the number of times a student attempts to pass the USMLE Steps. However, a majority of medical schools and state medical

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boards in the United States have established a limit to the number of times the exams can be taken.

At many medical institutions, passing the USMLE Step 1 examination is required for a student's promotion to the third year clinical clerkships and is particularly essential for graduation (Barzansky, Jonas, & Etzel, 1997). Our institution has required a passing performance on the USMLE Step 1 for graduation since 1992, and during the academic year 2001-2002, the policy was changed to make that a requirement for promotion to the third year clinical clerkships. The attention on student performance on the USMLE Step 1 has increased the need to identify accurate predictors of success. Several recent studies have revealed a number of variables (learning styles, performance on Medical College Admission Test (MCAT), student entry grade point average, age, gender, and race) that correlate with USMLE Step 1 performance (Case, Becker & Swanson, 1993; Elam & Johnson, 1994; Koenig, Sireci, & Wiley, 1998; Lynch, Woelfl, Steele & Hanssen, 1998; Swanson, Ripkey & Case, 1996; Wiley & Koenig, 1996). With the growing significance of students' performance on the USMLE Step 1, research to identify significant predictors of success on this standardized test has also substantially increased. Several studies have previously identified variables such as age, gender, race, learning style, entry level grade point average, the performance on Medical College Admissions Test (MCAT), and undergraduate and graduate grades that correlate with USMLE Step 1 performance (Case et al., 1993; Elam & Johnson, 1994; Koenig et al., 1998; Lynch et al., 1998; Swanson et al., 1996; Wiley & Koenig, 1996). Use of students' performance in the pre-clinical/basic science curricular courses as predictors of USMLE Step 1 scores has been under-explored although researchers have highlighted its importance (Holtman, Swanson, Ripkey, & Case, 2001). Previous research has indicated a correlation between students' performance in the medical gross anatomy course and the USMLE Step 1 score (Peterson & Tucker, 2005). In this study we evaluate the ability of two curricular measures and one extracurricular measure in predicting performance in the USMLE Step 1 examination.

The curricular measures evaluated in this study include the final percent scores achieved in two pre-clinical courses, Human Structure in the first year curriculum and Organ Systems in the second year curriculum. These two curricular measures were selected because they have the highest failure rate at our institution in the first two years of the curriculum. The Human Structure course is part of the first year curriculum; it integrates topics from gross anatomy, microanatomy, and embryology and contains gross dissections and microanatomy labs (The University of Toledo College of Medicine, 2008a). The Organ Systems course is the principal course in the second year of the curriculum. Topics are organized and based on nine major organ systems. These include the relevant physiology, pharmacology, and pathology for the following systems: Cardiovascular, respiratory, renal, electrolytes, hematopoietic, gastrointestinal, hepatic endocrinology, reproductive, skin, and skeletal (The University of Toledo College of Medicine, 2008b). The extracurricular measure evaluated as a predictor of USMLE Step 1 performance was scores on the Comprehensive Basic Science Examination (CBSE).

Methodology

The study was approved by the Institutional Review Board at the University of Toledo Health Science Campus (formerly known as the Medical College of Ohio). A total of 711 second-year medical students were included in this study. A brief description of the study was presented to the students at one of the USMLE Step 1 Preparation Program sessions offered by the institution's Academic Enrichment Center. The final percent scores for the Human Structure and the Organ Systems courses were obtained from the respective course directors. All students were required to take the paper and pencil version of the CBSE and were allowed a maximum of three hours to complete the test. The USMLE Step 1 was administered at one of the NBME approved testing sites of the student's choice. The majority of students opted to take their USMLE Step 1 at the institution's Academic Test Center, which is one of eight medical school testing sites in the nation that is approved by the NBME. Only the first time USMLE Step 1 scores obtained by the students were used in the analysis.

Data from five consecutive academic years (2002 through 2006) was combined for analysis (n=711). All the identifiers in the data were removed in order to maintain confidentiality. Statistical analysis included bivariate Pearson's correlation to test the strength of associations between the measures. Linear regression was performed using each of the three different measures separately and in combinations to identify the model that best predicts students' performance on the USMLE Step 1. Multivariate normality (normal distribution of the dependent variable for each combination of values of the predictors) was examined prior to the regression analysis. Multi-collinearity of the predictors was addressed using the standardized (z) scores in the analyses. The predictability (i.e., the ability to explain the variance in the dependent variable USMLE Step 1 score) was interpreted based on the value of adjusted coefficient of determination (R2). For all the models, quadratic and interaction terms were examined to increase the predictability. Significance of the difference between R2 values from different models were examined using the F statistic. Statistical analyses were performed using SAS 9.1 (SAS Institute, Cary, NC, U.S.A.).

Results

Descriptive statistics of the combined data from a total of 711 second-year medical students from five academic years (2002 through 2006) are presented in Table 1. The mean USMLE Step 1 score was 214.2 ± 21, the CBSE was 63.0 ± 7, and the final average percent scores in the Organ Systems and the Human Structure courses were 82.7 ± 7 and 80.9 ± 7 respectively. There were no statistically significant differences in the mean scores of the three measures across all five academic years.

Table 1.

Description of the curricular and extra-curricular measure scores from academic years 2002 to 2006.

	2002 – 2006 (n=711)
	Mean ± SD
Organ Systems Final Percent	82.89 ± 7.0
Human Structure Final Percent	81.06 ± 7.1
CBSE score	63.44 ± 7.0
USMLE Step1 score	214.6 ± 21.0

SD = standard deviation

All three measures significantly correlated with each other and with the Step 1 scores. A strong positive correlation ($r=0.74$, $p<0.001$) was observed between the two curricular measures. The strongest correlation was observed between the Step 1 scores and the performance in the Organ Systems course ($r=0.76$, $p<0.001$). Performance in the Human Structure course and the CBSE scores correlated moderately with the Step 1 scores ($r=0.65$, $p<0.001$ and $r=0.69$, $p<0.001$ respectively).

Table 2 illustrates the results from the simple regression analysis. Performance in each of the two pre-clinical curricular courses significantly predicted students' performance on the USMLE Step 1 examination. Students' final percent score in the Organ Systems course accounted for 59% of the variance in the Step 1 score and was a better predictor than the score in Human Structure course (42%). The CBSE course accounted for 51% of the variability in the Step1 scores.

Table 2.

*Simple regression predicting the USMLE Step 1 score**

	β	95% CI	p-value	R^2 (%), Intercept
Organ Systems	2.44	2.29-2.59	<0.001	59.6, 11.21
Human Structure	1.91	1.74-2.08	<0.001	42.3, 59.64
CBSE	2.16	1.99-2.32	<0.001	51.1, 77.42

*All regression models were significant at the 0.01 level (2 sided)
β = Regression coefficient; CI = confidence interval; R^2 = Coefficient of determination

Table 3 presents the multiple regression analysis with the two curricular courses in one model and together with the extra-curricular measure in a separate model. Predictability combining the final percent scores in the Human Structure and Organ Systems courses (adjusted R2=0.61) was noted as marginally better than that from the Organ Systems alone (R2 change=0.018, F change=30.17, p<0.001). However, using the score on the CBSE as an additional predictor along with both the curricular courses, a total of 69% of variance in the USMLE scores could be explained (R2 change=0.085, F change=180.93, p<0.001). All three measures significantly contributed to the overall predictability. No difference in the R2 value was noted in separate regression models that used the standardized scores or with the academic year as an additional variable. Use of the quadratic and interaction terms did not significantly contribute to the final models.

Table 3.

*Multiple regression predicting the USMLE Step 1 score**

MODEL	β	95% CI	p-value	Adj. R^2 (%), Intercept	Power	Standardized estimate
Organ Systems	1.97	1.76-2.19	<0.001	61.2, 4.14	0.99	0.631
Human Structure	0.57	0.37-0.77	<0.001		0.99	0.193
Organ Systems	1.48	1.27-1.69	<0.001		0.99	0.474
Human Structure	0.31	0.13-0.49	0.001	69.7, -4.29	0.91	0.107
CBSE	1.11	0.95-1.27	<0.001		0.99	0.369

*All regression models were significant at the 0.01 level (2 sided)

β = Regression coefficient; CI = confidence interval; R^2 = Coefficient of determination

With information from the regression analysis comprising all three predictors, an equation to obtain predicted USMLE Step 1 score was derived as follows: Predicted USMLE Step1 score = 1.48 (Organ Systems %) + 0.31 (Human Structure %) + 1.11 (CBSE raw score) - 4.29. Using this equation nearly 70% of the variability in the USMLE Step 1 score could be predicted.

Discussion

In this study, performance of students in two curricular courses and the comprehensive basic science examination was used to predict the USMLE Step 1 scores. To the best of our knowledge this is the first study to utilize a system-based curricular course such as Organ Systems to predict Step 1 performance. Our hypothesis was that the final percent achieved in the two curricular courses that have the highest failure rates in the pre-clinical curriculum at our institution would be good predictors of Step 1 performance. In addition, we selected the CBSE, a commercially available test that evaluates basic science knowledge, as an extracurricular predictor of Step 1 performance.

Results of this study demonstrated that all the evaluated measures were statistically significant predictors of USMLE Step 1 performance. Of the two pre-clinical courses in the College of Medicine curriculum, the final percent score in the Organ Systems course was a better predictor of USMLE Step 1 performance than that in the Human Structure course. At our institution, the Human Structure course is included in the first year curriculum while the Organ Systems course is part of the second year curriculum. The difference between the two curricular courses as predictors could be attributed partly to the distinct order in which the courses are offered in the pre-clinical years of medical education. Our findings also verify that the USMLE Step 1 practice test, CBSE, was a good independent predictor of Step 1 performance. The variability in the Step 1 scores explained by the CBSE in our study was similar to that reported in other studies (Elam & Johnson, 1994).

As single predictors, the final percent scores in the Organ Systems explained the maximum variability in Step 1 performance followed by the CBSE scores and the final percent scores in the Human Structure course. It can be suggested that along with the Step 1 practice tests, student achievement in the curriculum could be used to predict performance on the USMLE Step 1 examination. Combining the students' performance on the CBSE and in their two curricular courses increased the ability to predict USMLE performance and explained approximately 70% of total variance in the USMLE scores. This result suggests that institutional courses are good predictors of student performance on national standardized tests, and it is plausible that the teaching methodologies, format of the course, and/or learning methods in these courses play an indirect but significant role in the prediction.

Recognition of curricular courses as predictors of USMLE Step1 performance has several implications. It provides an opportunity for the educational authorities and committees at medical institutions to direct existing resources or dedicate additional efforts to improve students' performance in these courses, thereby ensuring better performance on the USMLE Step 1. With institution-specific prediction models using curricular courses, early identification of students at risk for failing the Step 1 could be possible. This provides an opportunity to intervene appropriately via intensive study strategies, tutoring and/or review programs that promise better USMLE Step 1 performance from the students.

Past research has suggested several different predictors of USMLE Step 1 performance including age, gender, race, learning style of the students, and preadmission variables such as entry level grade point average, undergraduate grades, MCAT performance, etc (Basco, Way, Gilbert & Hudson, 2002; Case, Becker & Swanson, 1993; Elam & Johnson, 1994; Kleshinski, Khuder, Shapiro & Gold, 2007; Koenig, Sireci & Wiley, 1998; Lynch, Woelfl, Steele & Hanssen, 1998; Wiley & Koenig, 1996). We acknowledge that our study lacks information on these predictors; however, earlier studies have indicated that many of these variables predict students' performance in the pre-clinical years of medical education (Haist, Wilson, Elam, Blue & Fosson, 2000; Höschl & Kozený, 1997; Julian, 2005). Therefore, it is plausible to assume that the observed predictability of basic science curricular courses in this study is influenced by other predictors as indicated above. Nevertheless, a student's performance in the curricular courses could serve as a convenient, reliable,

and convincing predictor of the USMLE Step 1 score. Other limitations of this study are that the data included in the analysis was from a single medical institution, and the sequence in which the two curricular courses are offered to the students could have influenced the predictions. As specified earlier, the basis for selecting the Organ Systems and Human Structure courses in our analysis was the high failure rate noted among the students over the past five years. A lack of variability in students' performance in the other courses of the first and second year curriculum accounted for their exclusion in this study. One of the strengths of this study includes a large sample of medical students included from multiple consecutive academic years. In addition, performance on the USMLE Step 1 was assessed by the actual score on the test with linear data analysis, not by pass or fail based on a cutoff score.

Implications and Further Study

Implications of this study can be directed towards the role of learning centers in academic institutions, their influence on student performance in curricular courses, and ultimately on the national licensure examinations. Future research efforts should focus on developing strategies that improve student curricular performance and methods to evaluate their outcome on the standardized examination.

Conclusion

Our study supports that select pre-clinical curricular courses of medical education are convenient and good predictors of student performance on the USMLE Step 1. Efforts for improving student performance in these courses will culminate in better performance on the standardized licensing examination. Some of the techniques that could potentially improve student curricular performance are the following: types of tutoring (supplemental instruction, structured learning assistance programs, individual and group tutoring) and a variety of teaching methods that take into account multiple types of learning styles. Additionally, this would also increase students' self-esteem, self-confidence, and future accomplishment throughout their medical careers. Student success on the USMLE Step 1 improves the overall institutional performance which is important for accreditation of medical schools by the Liaison Committee for Medical Education, as well as for the ability of the institution to attract highly qualified students and residents.

References

Barzansky, B., Jonas, H.S., & Etzel, S.I. (1997). Educational programs in US medical schools, 1996-1997. *JAMA 278*(9), 744-9.

Basco, W.T., Way, D.P., Gilbert, G.E. & Hudson, A. (2002). Undergraduate institutional MCAT scores as predictors of USMLE step 1 performance. *Academic Medicine 77*(10), S13-16.

Case, S.M., Becker, D.F., & Swanson, D.B. (1993) Performances of men and women on NBME Part I and Part II: The more things change... . *Academic Medicine 68*, S25-S27.

Elam, C.L. & Johnson. M.M. (1994). NBME Part I versus USMLE Step 1: Predicting scores based on preadmission and medical school performances. *Academic Medicine 69*, 155.

Federation of State Medical Boards and National Board of Medical Examiners. (2008). *United State Medical Licensure Examination Bulletin* 2008. Retrieved January 20, 2008, from http://www.usmle.org/General_Information/bulletin/2008.html.

Haist, S.A., Wilson, J.F., Elam, C.L., Blue, A.V. & Fosson, S.E. (2000). The effect of gender and age on medical school performance: An important interaction. *Adv Health Sci Educ Theory Pract 5*(3), 197-205.

Holtman, M.C., Swanson, D.B., Ripkey, D.R. & Case, S.M. (2001). Using basic science tests to identify students at risk for failing Step 1. *Academic Medicine 76*(10), S48-S51.

Höschl, C. & Kozený, J. (1997). Predicting academic performance of medical students: The first three years. *Am J Psychiatry 154*(6), 87-92.

Julian, E.R. (2005). Validity of the Medical College Admission Test for predicting medical school performance. *Academic Medicine 80*(10), 910-917.

Kleshinski, J., Khuder, S.A., Shapiro, J.I. & Gold, J.P. (2007). Impact of preadmission variables on USMLE step 1 and step 2 performance. *Adv Health Sci Educ Theory Pract* (In press).

Koenig, J.A., Sireci, S.G., Wiley, A. (1998). Evaluating the predictive validity of MCAT scores across diverse applicant groups. *Academic Medicine 73*, 1095-1096.

Lynch, T.G., Woelfl, N.N., Steele, D.J., & Hanssen, C.S. (1998). Learning style influences student examination performance. *American Journal of Surgery 176*, 62-66.

Peterson, C.A. & Tucker, R.P. (2005). Medical gross anatomy as a predictor of performance on the USMLE Step 1. *The Anatomical Record* (*Part B: New Anat*) *283*(1), 5-8.

Swanson, D.B., Ripkey, D.R., Case, S.M., & Validity Study Group for USMLE Step 1/2 Pass/Fail Standards 1994-95. (1996). The relationship between achievement in basic science coursework and performance on 1994 USMLE Step 1. *Academic Medicine 71*(1), S28-S30.

The University of Toledo College of Medicine. (2008a). Year 1 curriculum. Retrieved January 20, 2008 from http://hsc.utoledo.edu/med/preclinical/curriculum1.html

The University of Toledo College of Medicine. (2008b). Year 2 curriculum. Retrieved January 20, 2008 from http://hsc.utoledo.edu/med/preclinical/curriculum2.html

Wiley, A. & Koenig, J.A. (1996). The validity of the Medical College Admissions Test for predicting performance in the first two years of medical school. *Academic Medicine 71*, S83-S85.